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Statement of
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Committee on Commerce, Science, and Transportation
United States Senate

Mr. Chairman and Members of the Subcommittee:

I am pleased to be here today in response to your request that I provide testimony on several Agency programs, and I congratulate you for holding this hearing that focuses on NASA's failures. As you know, my own management style is to focus on what we need to do better, even while recognizing that almost all of what NASA does is done successfully. We learn from correcting our mistakes, by identifying the lessons learned from our endeavors and then ensuring that other programs apply those lessons. NASA is a research agency operating at the cutting-edge of science and technology. Even though we strive for excellence, we also must be aware that space launch vehicles and spacecraft must operate in an environment that is extremely unforgiving.

We have recognized these challenges ourselves, and, on our own initiative, have proactively initiated a series of reviews. At the same time, I salute the NASA team; they are wonderful men and women experimenting with change. I welcome this opportunity to give you our preliminary assessment today of the several reviews that have been conducted and the reports that have been issued. We intend to reflect further, and would be pleased to return later this summer to outline our conclusions.

Mr. Chairman, I understand that the Subcommittee's focus today is upon management issues, but I would like to remind the Subcommittee that NASA's record of accomplishment has been outstanding. I am proud of our record of having saved approximately $40 billion from planned budgets for the American taxpayer, and doing more for less. As testimony to the performance of the NASA team, since 1992, NASA has launched 146 payloads valued at a total of $18 billion. Of this number, 136 payloads were successful. We believe our success is a testimony to NASA's strong systems engineering capability. Our total losses amounted to 10 payloads, measured at about $1/2 billion, or less than 3 percent. The Mars 1998 failures alone accounted for 60% of this loss. Planetary spacecraft, which used to be launched twice a decade at a cost measured in the billions, are now routinely launched each year at a small fraction of that cost. This is world class performance by any reasonable standard. I would like to recount a few of the successes of the past year.:

* We began the year with the successful launch of Deep Space One, a mission to test 12 revolutionary technologies necessary for the future of space science.

* STS-93, commanded by the first female Shuttle commander, deployed the Chandra X-ray Observatory;

* Deployment of the EOS series of satellites was begun, with the launch of Landsat 7, followed by QuikSCAT, Terra, the flagship EOS satellite, and AcrimSAT.

* The X-33 program made considerable progress by beginning testing of the world's first aero-spike engine, scheduled to be completed this summer;

* ISS hardware to support the first 12 ISS assembly missions was completed and stands poised for launch at the Kennedy Space Center.

* On STS-103, we repaired the Hubble Space Telescope (HST), and HST has now found a value for how fast the universe is expanding, after 8 years of painstaking measurement; and,

* STS-99, the Shuttle Radar Topography Mission (SRTM) achieved a breakthrough in remote sensing that will produce topographic maps of Earth 30 times as precise as the best global maps in use today.

As you know, 1999 was marked by continuing launch vehicle failures that directly and indirectly impacted NASA programs. The Russian Proton failures have had a significant impact on the launch of the Russian Service Module Zvezda. The Japanese, Europeans, and the United States struggled to achieve safe and reliable access to space. Just two weeks ago, the Sea Launch vehicle experienced a failure. And, in 1999, NASA also experienced some severe disappointments and problems: the back-to-back losses of the Mars Climate Orbiter and the Mars Polar Lander and the Deep Space-2 probes, wiring problems and a hydrogen leak in the Shuttle, and a failure of the X-33 composite tank to pass a qualification test.

You have specifically requested that I address the Mars Program failures as well as delays in Space Shuttle launches, the International Space Station, X-33, and Gravity Probe B. You also asked me to specifically address the manner in which NASA is using systems engineering to facilitate the successful conduct of these missions.

A number of independent reviews have been commissioned to examine these problems, search for root causes, and recommend changes. NASA worked closely with the Department of Defense and others on the Broad Area Review of DOD space launch failures. In July 1999, NASA requested that the former Mars Pathfinder Project manager conduct a study of NASA's approach to Faster, Better, Cheaper (FBC) program management, and make recommendation on a set of principles, tools, and processes for ensuring NASA's success in adapting the FBC approach to project planning, management and execution. In response to ascent anomalies observed on STS-

93, NASA, in September 1999, chartered a Space Shuttle Independent Assessment Team (SIAT). The objective of the SIAT was to undertake a technical review of Shuttle maintenance and operations, and to bring to the Space Shuttle, where applicable, best practices of the external commercial and military aviation community. In October 1999, NASA chartered a Mars Climate Orbiter (MCO) Mishap Investigation Board to assess the actual or probable cause of the MCO mission failure. Following the loss of the Mars Polar Lander, the charter of the Board was expanded to investigate a wide range of space science programs, and to make recommendations regarding NASA project management based upon lessons learned from the expanded review. In November 1999, NASA and Lockheed Martin formed a review team to assess the causes and implications of the X-33 Liquid Hydrogen Composite Tank failure.

Additionally, following the failures of the Mars Climate Orbiter, the Mars Polar Lander, and two Deep Space 2 microprobes, I determined that an in-depth review of the entire Mars Program should be undertaken by independent observers. The Mars Program Independent Assessment Team (MPIAT) was chaired by A. Thomas Young. The MPIAT report is expected to be released by the end of March, and the independent review of the X-33 tank failure is scheduled to be completed in the coming weeks. I will refrain from commenting upon either of those reports today.

As you can see, NASA has taken the initiative to commission these reviews and examine ourselves. Within the last two weeks, the reports of the Shuttle Independent Assessment Team, the Mars Climate Orbiter Mishap Investigation Board, and the Faster, Better, Cheaper Review have been issued. The reports will be made part of today's hearing record, and you will hear from the leaders of each team today. Some of the common findings from these reports are:

* in many cases, program managers did not employ the risk management tools that would have alerted them to the inadequacy of their budget, schedule and performance margins, with the consequence that risk levels were higher than anticipated, particularly in missions with fixed launch dates, fixed launch vehicles, and fixed science payloads;

* at a time of major cultural change and a rapid increase in the number of programs underway, programs were staffed with next-generation program managers without, in some instances, ensuring that they had been adequately trained and mentored, both in terms of resources for lessons learned from past experiences and the use of revolutionary new tools and techniques.

* there have been instances in which problems have been observed, but not effectively communicated; and,

* in some cases, employees have not adhered to sound engineering and management principles and Agency standards and procedures with respect to timely, independent peer review of scientific and technical approaches being used to achieve program goals.

In summary, these findings convey a less than desired effectiveness of our project management and systems engineering practices with respect to the failed missions.

These reports, and the pending Mars Program Independent Assessment Report, will provide a set of findings and recommendations that can serve as a strong foundation for executing the changes in NASA program architecture, management, systems engineering, design, and execution needed in the future. As has been the case at various times throughout this Agency's 40-year history, NASA is committed to learn everything we can from these losses, alter our approach where it is prudent to do so, and move on. NASA has undertaken a journey toward revolutionary change with the strong support of the Administration and Congress.

These failures are not a basis for reversing our present course in pursuit of revolutionary change. And NASA will not reverse course. We are committed to fixing our shortcomings and moving forward. However, I believe it would be unwise to issue a prescription for mission success to the NASA workforce. They must have the freedom to innovate and learn. At the same time, there are fundamental considerations that must be taken into account. We must ensure that clear and independent peer review of scientific and technical approaches is done. It is essential that men and women being placed in new positions of responsibility and new technical assignments be trained and mentored, not only in terms of retrospective experiences and leadership, but prospectively as well, in terms of what we are already learning from revolutionary new tools and techniques. Criteria for mission success must be clearly articulated. Resource estimates must be commensurate with mission goals. Margins must be adequate. And there must be clear lines of communication up and down the management chain, allowing for open discussion. These fundamental considerations were not applied as they should have been in the Mars 1998 missions. As I stated before this Committee in 1997, "At NASA we do not shy away from difficult missions. NASA has tremendous successes, but we also have failures and we learn from them. Often the learning we do from our failures leads to greater successes than we originally imagined. That is why it is important for young people to see NASA take risks. We want them to see that we are not afraid of failure, and that they should not be either."

There is no prescription that can eliminate the chance of failure. And success cannot be prescribed just by returning to past techniques for conducting missions. Imposition of prescriptions for mission success runs the risk of suffocating openness to change, risk taking, and willingness to fail. Prescription does not work because it does not allow for innovation and incorporation of new concepts and technology. We must recognize that we are at the leading edge of a transition toward a new generation of scientists and engineers. We need to examine failures experienced by NASA, other Government agencies, U.S. industry, and throughout Europe, Japan, and Russia. Within the broader context of the advanced development and science base of the United States, we are witnessing a demographic change. The engineering experience base of Apollo and the Cold War is retiring from the work environment, at the same time that NASA is facing very tough competition from dot.com organizations and the high tech industry for the best engineers and scientists emerging from our universities. Simultaneously, we are witnessing the emergence of new technologies and new approaches to engineering. Soft computing, neural networks, and learning systems, are being incorporated into design and operations to enable more fault-tolerant systems rather than reverting to techniques of the past. The United States must be at the forefront of these new approaches to engineering, and must have a new engineering education curriculum to prepare its new engineers. NASA is fully engaged in these new directions in engineering and design tools, in information technology, nanotechnology, biotechnology and Intelligent Synthesis Environments. A key element of the Intelligent Synthesis Environment is Advanced and Collaborative Engineering Environments. These engineering environments were highlighted in the Phase I June, 1999 report of the National Research Council on Advanced Engineering Environments as a historic opportunity to create facilities and tools in collaboration with industry and academia to design, analyze, and conduct performance trade studies of complex systems with unprecedented levels of effectiveness in terms of time, cost and labor.

NASA has taken proactive steps with the development of such tools, methods and facilities at NASA Centers since the early 1990's. The Project Design Center at JPL, and the Integrated Mission Design Center at GSFC are two examples of the application of such environments early in the formulation process to define requirements, develop design concepts, conduct performance trade studies, assess technology benefits, and provide parametric cost data on complex NASA missions. These environments also provide an opportunity to capture lessons learned in systems engineering designs and analysis. All of these are responsive to some of the concerns raised in the MCO and FBC reports and clearly represent a visionary step to take full advantage of the information, design and analysis tools revolution. The Agency recognizes that further integration into the physical and cultural infrastructure of the Agency is needed. The Aero-Space Technology Enterprise has already taken steps with its Lead Centers to develop business plans to address such concerns.

I want to salute the Mars 1998 team. They pushed the envelope. The mistakes made can and will be corrected. Learning from those errors will enable NASA to strive for even greater accomplishments in the future. The entire NASA team, civil servants and contractors, has done an incredible job in the face of change and transition to Faster, Better, Cheaper.

Mr. Chairman, let me also say that I believe strongly that delays in launch are not a measure of failure. Your concern about delays, and the consequent costs, is well taken. However, NASA is all too aware that rushing to launch when mission success issues have not been resolved increases the potential for failure. In fact, NASA is deliberately encouraging a culture change in which any person can speak up to stop a program or launch if it is not ready, or if it is unsafe in terms of hardware or crew. We are modifying NASA's performance goals and renegotiating contracts to remove the emphasis upon schedule, and refocus emphasis upon better design and quality.

I salute our employees for their determination to delay launches of the Shuttle this past year until they were convinced we could safely launch. There are other instances, some involving delays of spacecraft valued at more than $1 billion, in which we have employed new tools and techniques with which our employees have demonstrated that they are empowered to identify problems prior to launch in order to fully resolve those issues.

* In the case of AXAF, NASA delayed shipping the spacecraft to verify software and faulty printed wiring boards were safe to fly.

* In the case of the Hubble Space Telescope servicing mission, we delayed the launch to complete inspection, maintenance and repair of Shuttle wiring.

* In the case of Terra, we delayed the launch to ensure that the launch vehicle propulsion system was safe following a previous Atlas IIAS failure.

* In the case of Deep Space-1, the team at the Jet Propulsion Laboratory had problems; they delayed the launch, added resources, and fixed it.

* In the case of the SRTM mission, a delay to upgrade the Shuttle allowed for additional analysis

and simulations to enhance safety and mitigate risk, helping us to better deal with an in-flight anomaly. The ultimately stunning results will benefit a variety of civil and national security interests.

Mr. Chairman, NASA is in the process of addressing the various recommendations included in these reports.

I have directed the NASA Chief Engineer to work with the four NASA Enterprises and NASA's Centers to develop an integrated implementation plan in response to recommendations emanating from all these reports for improvement in Program/Project Management and systems engineering and for the improvement of NASA's institutional infrastructure with respect to people, process tools, and technology. Actions will be defined in consultation with Enterprise managers, the NASA Academy of Program/Project Leadership, a training arm of the Agency's Office of Human Resources, the Program Management Council Working Group, an Agency-wide team of experienced project managers and system engineers and the various review groups. To accomplish this, the Chief Engineer will form an internal team of experts to assess all recommendations and develop Agency-wide approaches for improving the success of the Faster, Better, Cheaper class of missions. By August 2000, specific actions will be defined to ensure consistency of best practices during the formulation and implementation of programs and projects. Promulgation and deployment of the resultant actions will begin immediately thereafter. As I indicated earlier in this statement, the team will complete their proposed improvements by midsummer. I anticipate that those actions will result in revisions to:

* Agency policy and requirements for program/project management regarding staffing, systems engineering, risk management, peer reviews and other best practices as well as leadership plans;

* Agency approaches to attracting, developing, and retaining key engineering and project management skills;

* increased utilization of information technology-based tools to aid project execution during all phases; and,

* heightened attention to development of future mission technology needs.

Mr. Chairman, I would like to outline a series of proactive steps that NASA has undertaken during the past 2 years that are intended to strengthen our systems engineering capability and which, when fully operational, will help address many of the recommendations included in the various reports. These steps reflect NASA's commitment to world-class systems engineering throughout Agency programs.

* NASA deployed an Agency-wide NASA Policy Directive 7120.4, in November 1996, for Program/Program Management, and NASA Procedures and Guidelines NPG 7120.5, in April 1998, for NASA Program and Project Management Processes and Requirements. The processes and requirements defined by these documents are an integral part of the Agency-wide management system established to meet goals of NASA's Strategic Plan. This management system provides the framework to govern the formulation, approval,

implementation and evaluation of Agency Programs and Projects.

* A NASA-wide Core Competency assessment was undertaken in FY 1999 to define the requisite NASA workforce skills in all critical areas to accomplish Agency missions. One outcome of this activity was reflected in the Administration's FY 2001 budget request to add additional civil service staffing, following a 20-25% staffing reduction over the last several years.

* An Agency-wide working group has formulated a revised policy on program/project management focused on enhancing Risk Management and the establishment, in October 1999, of a Systems Management Office at each Center, led largely by senior project managers and systems engineers, to ensure requirement traceability and adherence to sound systems engineering practices. Additionally, a focused effort has been undertaken to safely reduce civil servants assigned to operational tasks and to redeploy those resources to Research and Development activities compatible with the Agency's strategic thrust.

* An Agency-wide focus on safety was implemented last summer. The motto "Mission Success Starts with Safety" is intended to ensure that the NASA and contractor workforce remain vigilant in keeping safety (including the safety of ground and space assets) the #1 core value. As part of this continuing focus, NASA, in concert with the Aerospace Safety Advisory Panel, is highlighting opportunities to design for safety. A renewed emphasis will be placed on Failure Modes and Effects Analysis (FMEA), fault tree analysis, and probabilistic risk analysis in all of our projects and programs.

* The position of Deputy Chief Engineer for Systems Engineering was established in February 2000, and filled with a highly experienced person, in order to ensure increased attention to sound systems engineering practices throughout the Agency. Responsibilities of this position include the development of the vision, strategies and objectives for the development and maintenance of a world class engineering capability. This includes assessing the discipline and systems engineering workforce (quality, quantity, capability, recruitment, training, life long learning, work experience, and organization), enabling tools, facilities and methods, and the development of action plans for continuous improvement.

* An Engineering Excellence Working Group has been established to develop the vision, strategies and objectives for the development and maintenance of a world class engineering capability throughout the Agency. As part of the Engineering Excellence initiative, the Chief Engineer is formalizing an Agency-wide Systems Engineering Working Group (SEWG). The SEWG will work closely with the Engineering Management Council in guiding the assessment of the discipline and systems engineering workforce, enabling tools, facilities and methods, and the development of action plans for continuous improvement.

* NASA is placing increased emphasis on performing rigorous independent verification and validation of mission success-related software by enhancing the capability and responsibility of the NASA IV&V Facility.

* For each of the 26 missions scheduled for launch in 2000, a rigorous independent "Red Team" review has been conducted to ensure that cost and schedule considerations have not inappropriately influenced prudent risk decisions. Some of these reviews have already led to

launch delays because of concerns raised. Additional risk mitigation measures stimulated by these reviews have already demonstrated enhanced success on the Shuttle Radar Topography Mission (SRTM).

* In order to improve the approach to independent assessment of projects, the Chief Engineer has been tasked to better integrate the full set of Agency, Enterprise, program and project reviews to assure effective balance of performance, cost, schedule, and risk considerations by the project and appropriate awareness of those considerations by management.

Mr. Chairman, I understand that you are considering introducing legislation that would require NASA to develop a systems engineering plan and implement it for every mission. We believe that appropriate responses to recent mission failures, particularly the planetary failures, must be the product of a comprehensive evaluation, to ensure that both the root causes and contributing causes are addressed. All the steps I have outlined above are designed to produce an integrated Agency response to report findings and to simultaneously strengthen our program management. We do not believe that success can be prescribed with legislation. We know that you care about the success of NASA's program, and that you want to help. Rather than pursuing a legislated prescription for systems engineering, we propose instead that you permit NASA to complete our assessment and provide you the result of our integrated response by late summer.

I know that you and the other Members of this Subcommittee share NASA's objective to secure the maximum return on the investment of the American taxpayer in cutting-edge research and technology. I again commend you for focusing your attention on our recent mission losses, so that we can have a full and open dialogue on how we intend to address them. NASA remains fundamentally committed to revolutionary change so as to provide our Nation the highest quality space and aeronautics program. I have appended to my statement detailed information concerning the reports of the SIAT, the MCO Mishap Investigation Board, and the Faster, Better, Cheaper Review, as well as detailed information concerning program status of the Space Shuttle, International Space Station, X-33 and Gravity Probe B programs, as requested in your letter of invitation.

Thank you. I would be pleased to respond to your questions.